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THE PATENT OFFICE
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16 SEP 2002
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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

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1. Your reference — 8714 GB/DTD

175EP02 E748629-2 D00001
P01/7700 0.00-0221451.8

2. Patent application number
(The Patent Office will fill in this part) — 16 SEP 2002 — 0221451.8

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

MOLECULAR OXYGEN LIMITED
Mill End
Thaxted
Essex
CM6 2LT

08465635001
Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

4. Title of the invention — Gas Generator

5. Name of your agent *(if you have one)* — Abel & Imray

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

20 Red Lion Street
London
WC1R 4PQ
United Kingdom

Patents ADP number *(if you know it)* — 174001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	7
Claim(s)	2 DMC
Abstract	1
Drawing(s)	

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Abel & Imray Date 16.09.02

12. Name and daytime telephone number of person to contact in the United Kingdom: David T. Darby - 020 7405 0203

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GAS GENERATOR

This invention relates to gas generators, more especially oxygen generators, and in particular to a generator for providing breathable oxygen.

Breathable oxygen generation by a chemical reaction has been known for a very long time, and portable oxygen candles are articles of commerce. A typical candle comprises an oxygen-containing chemical, for example an alkali metal chlorate or perchlorate, in admixture with a catalyst that facilitates lower temperature decomposition of the chemical to oxygen and residual solids and optionally a fuel, for example iron. A typical catalyst is manganese dioxide, which reduces the temperature at which potassium chlorate decomposes from about 400°C to below about 240°C.

However, the overall reaction is exothermic, and the exterior of the reaction mass generally reaches very high temperatures, of the order of 600°C or more. Considerable efforts have been made to provide portable devices that can safely be held by the user during operation despite the high temperatures reached during the reaction.

A number of thermally insulated devices are described in U.S. Patent No. 5 725 834 (Nishii *et al*, assigned to Daicel Chemical Industries, Ltd.). The patent describes a prior art device in which silica is used as thermal insulation, which has the dual function of maintaining the exterior of the housing at an acceptably low temperature and maintaining the interior of the candle at a high enough temperature to ensure decomposition of all contained materials, to maximize oxygen output. In one embodiment of the Nishii invention itself, a cylindrical candle is surrounded by porous solid insulation within a copper jacket which is separated by an annular air space from the housing. The oxygen generated passes through

the insulation to an outlet of the device at the head of the cylinder. In other embodiments there are more coaxial airspaces and the generated oxygen traces a convoluted passage through them, ensuring that it is cooled before reaching the user, and that the outer surface of the housing does not get too hot. All these measures, while being effective, inevitably add bulk and weight to the device.

There accordingly remains a need for an insulated gas generator the thermal insulation of which may result in apparatus that is lighter and less bulky than existing apparatus.

The present invention provides a chemical gas generator comprising a generating device producing gas by chemical reaction, the device being at least partly enclosed within thermal insulating means comprising a vacuum jacket.

Advantageously, the gas generated is oxygen, and for simplicity will be referred to as such in much of the discussion below. The invention is, however, applicable to generators of other gases.

The generator is typically generally in the form of a cylinder, referred to hereinafter as a candle. The candle may be a cast body or a loose-filled or compacted powder, pelletized, or granular material. The candle advantageously comprises a metal chlorate or perchlorate, preferably an alkali metal, especially sodium or lithium, chlorate or perchlorate, in admixture with a catalyst, especially manganese dioxide, and a metal, especially iron or magnesium. The candle is provided with ignition means, which may be electrically powered or operated by percussion cap or chemical reaction. The ignition means may be at one end of the candle or centrally located to provide two burn fronts travelling in different directions, preferably opposite directions towards the ends of the candle. The invention

accordingly also provides an oxygen generator in which the generating device comprises:

(a) generating means for chemically generating oxygen when ignited and

(b) ignition means for igniting the generating means, the generating means being arranged to sustain during operation propagation of a plurality of, preferably two, burn fronts therethrough, the fronts propagating in generally different, preferably opposite, directions, the device being at least partly enclosed within thermal insulating means comprising a vacuum jacket.

A burn front is the interface region bounded by unburnt and burnt regions of the generating means, and in operation travels towards the unburnt region.

The provision of the ignition means at a central region of the candle has the advantage that the ignition site, which becomes the hottest part of the candle, is remote from re-usable parts of the generator, e.g., electrical circuitry if electric ignition is used. Further, the use of two or more burn fronts dissipates the heat generated over a wider area and assists in the control of the burn process.

The oxygen generating means may, for example, comprise at least one first element positioned and arranged for ignition by the igniting means, and a plurality of second elements each positioned and arranged for ignition by a first element, so that in operation a plurality of burn fronts is propagated through the at least one first element and through the plurality of second elements, the direction of propagation of one of the burn fronts differing from the direction of propagation of at least one other of the burn fronts.

The ignition means may, for example, be located in the central region of an oxygen generator of a generally cylindrical shape, the length of the generator being greater

than its diameter so that in operation two burn fronts are propagated from the central region toward opposite ends of the generator. In this case also, there are preferably provided at least one first element of the generating means arranged for ignition by the ignition means and a plurality of second elements for ignition by a first element. There may be a succession of elements extending toward one or preferably both ends of the generator, each arranged for ignition by the immediately preceding element.

Whether the ignition means is at one end or centrally located, elements adjacent to and closer to the ignition means are advantageously more reactive than elements more remote from it, to improve stability of the candle and render it less susceptible to accidental ignition. Step-wise gradation of the elements facilitates manufacture, as each element has a uniform composition, and the candle is then assembled from discrete components. The interfaces between elements may be of conical or frusto-conical form, assisting in control of burn front propagation between adjacent elements.

The ignition means may be, for example, an electrically resistive heating device, a percussion cap detonator or a cartridge ignition device, or an exothermic chemical reaction, initiated, for example, by causing or allowing contact between previously separated reagents. If desired, the candle may include more than one type of ignition device. Electrically resistive heating devices are preferred, being intrinsically safe until energized.

Preferably, the ignition means comprises a resistive heating device, and the generator further comprises electronic control means for controlling electrical power applied to the heating device to initiate combustion. Use of electronic control means enables an improved degree of ignition control to be achieved. The control means

preferably includes coupling means for inductively coupling electrical power from the control means to the heating device; such inductive coupling is of benefit in that exposed electrical contacts may be avoided in the generator, such contacts being susceptible to oxidation and being potentially unreliable.

To conserve battery power and yet ensure reliable ignition of the generating means, the control means may include timing means for automatically controlling the period during which electrical power is applied to the heating device for initiating combustion.

When electrical or electronic ignition is employed, the control means advantageously includes at least one, preferably more than one, battery providing power for the ignition means to initiate oxygen generation, the control means further comprising battery monitoring means for monitoring remaining power deliverable from the at least one battery. The monitoring means indicates to a user the status of the battery needs.

The monitoring means advantageously includes a light emitting diode indicator and/or a liquid crystal display indicator for indicating remaining power deliverable from the battery or batteries. Light emitting diode indicators are more visible in subdued lighting, for example at dusk or night-time, whereas liquid crystal display indicators are more visible in strong illumination, for example in bright sunlight.

More details of a gas generator having these features are given in International Patent Application No. PCT/GB02/02603.

The candle is advantageously provided with an apertured, for example perforated, casing, for example, of gauze, of a material, preferably a metal, of high thermal conductivity, for example copper or brass, in good thermal contact with the

candle material. The casing transmits heat from the burn front and the burnt region to the unburnt region or regions, thereby pre-heating the unburnt region and help establish an even burn. The perforations provide channels for the oxygen to flow.

An intermediate layer or layers of insulation may be provided between the candle or the casing if present and the vacuum jacket. This insulation may be rigid or flexible, for example, of ceramic, rockwool, or particulate material.

The candle is at least partially contained within a vacuum-jacket vessel. The vessel is advantageously of complementary shape to the candle, or to the casing if present, clearance being provided between the internal wall of the vessel and the peripheral wall of the candle to allow oxygen to reach the outlet, a spacer or spacers being provided to secure the position of the candle within the vessel. The spacer or spacers may be shaped to provide a tortuous path for the oxygen to follow to allow some cooling before reaching the outlet of the generator.

The vacuum-jacket vessel may be of any material capable of withstanding the temperatures reached by the burning candle; a steel, preferably stainless steel, vessel is presently preferred. Alternatively, a robust glass vessel, for example, a borosilicate glass vessel may be used.

A spacing between inner and outer walls of the vessel in the range of from 3 to 5 mm is presently preferred. The vessel is evacuated to provide a high vacuum, advantageously in the range of from 10^{-7} to 10^{-5} mbar (0.01 to 10 Pa), for example about 10^{-6} mbar (0.1 Pa).

The generator according to the invention may be provided with means to blend the oxygen produced with atmospheric air, to deliver oxygen-enriched air, rather than pure oxygen, to a user. The generator may also be provided with a chlorine absorbent to absorb any traces of chlorine generated with the

oxygen; the copper or brass used as a casing may perform this function also, or additional copper or brass for example, in particulate form, may be provided in the oxygen pathway.

The following Example illustrates the invention.

An oxygen generator constructed in accordance with the invention comprises a sodium chlorate-based candle encased in a copper gauze and delivering 90 litres of USP oxygen at a rate of 6 litres per minute.

The encased candle had a length of 12 cm and a diameter of 3.5 cm, and was encapsulated in insulation material and then in a vacuum flask of length 17 cm, internal diameter 6 cm and external diameter 7 cm. The generator weighed 0.6 kg and had a total length of 17 cm. In operation, the highest temperature reached at the exterior of the flask was 50°C.

For comparison, a generator commercially available from Molecular Products Limited and containing an identical candle was tested. The candle was insulated by rockwool and ceramic material. The total weight of the generator was 0.5 kg, its length was 13 cm and its diameter 10 cm. In operation, the highest exterior temperature reached was 150°C.

CLAIMS:

1. A chemical gas generator comprising a generating device producing gas by chemical reaction, the device being at least partly enclosed within thermal insulating means comprising a vacuum jacket.

2. A generator as claimed in claim 1, which generates oxygen.

3. A generator as claimed in claim 2, wherein the device comprises a metal chlorate or perchlorate, in admixture with a catalyst and optionally a fuel.

4. A generator as claimed in claim 3, wherein the device comprises sodium chlorate, manganese dioxide, and iron.

5. A generator as claimed in any of claims 1 to 4, wherein the device comprises electrically powered ignition means.

6. A generator as claimed in claim 5, wherein the ignition means is located in a central region of the device.

7. A generator as claimed in claim 6, wherein the generating means is arranged to sustain during operation propagation of a plurality of burn fronts therethrough, the fronts propagating in generally different directions.

8. A generator as claimed in claim 7, wherein in operation there are two burn fronts travelling in opposite directions.

9. A generator as claimed in any of claims 1 to 8, wherein the device is provided with an apertured casing of a material of good thermal conductivity.

10. A generator as claimed in claim 9, wherein the casing is of metal gauze.

11. A generator as claimed in any of claims 1 to 10, wherein the vacuum jacket vessel is of stainless steel.

12. A generator as claimed in any one of claims 1 to 11, wherein the pressure in the interior of the jacket is in the range of from 10^{-7} to 10^{-5} mbar.

13. A gas generator as claimed in claim 1 and substantially as described in the Example.

GAS GENERATOR

ABSTRACT

A gas generator insulated by a vacuum jacket vessel.